THE
STARDUST
UNIVERSE
ADVAITH V

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This book contains references and content about all the constellations, planets, habitable planets and telescope with rockets.

This book is available as an E-Book and is also available in printed format.

Thank you for choosing and reading this book.

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CHAPTER 1

INTRODUCTION

"Information is Wealth"

Welcome to The Stardust Universe and one of the most fascinating sciences in the universe! Whether you're familiar with the night sky and want to learn more about what's "out there" or just beginning your cosmic journey of understanding, there's something here to teach and inspire you.

Nowadays, astronomers spend time communicating astronomy to the public because they want others to experience the thrill of wonder and discovery that keeps astronomers going. They often give presentations about astronomy on cruise ships and other public places, and the questions people ask about the stars and planets are always fascinating and well thought out. It shows me that the love of the stars is bred into all of us—and makes us want to know more about the cosmos.

In The Stardust Universe, you get a taste of the cosmos. Astronomy is the scientific study of objects in the universe

and the events that shape them. It is one of the oldest sciences and dates back to a point in human history when people first looked up at the sky and began to wonder about what they saw. Astronomy tells how the universe works by looking at what it contains. The cosmos is populated

with stars, planets, galaxies, and galaxy clusters, and these are all governed by measurable physical laws and forces. Each topic in this book gives you a taste of the subject it covers, from planets out to the most distant objects in the universe, introducing you to some of the people who have done astronomy, and venturing into some “far out” topics, such as extraterrestrial life and the science-fiction universes familiar to TV viewers, moviegoers, video gamers, and readers. Throughout the book, This book is woven in some basic concepts about astronomy and space, such as how orbits work and how to calculate distances in space.
Finally, although this isn’t a “how to” book, in the final chapter, I leave you with a few thoughts about how to go about exploring the universe from your backyard and how we can all work together to mitigate light pollution—the scourge of all sky gazers.
You can read this book from start to finish, or pick and choose the topics you want to read. Each one gives you a unique insight into the endlessly fascinating universe. And, if what you read spurs you on to more investigation, the reference section at the back points you to further reading

WHY DO PEOPLE DO ASTRONOMY?

The astronomer Carl Sagan once said that modern people are descendants of astronomers. Humans have always been sky watchers. Our earliest ancestors connected the motions of the Sun, Moon, and stars to the passage of time and the yearly change of seasons. Eventually, they learned to predict and chart celestial motions. They used that information to create timepieces and calendars. Accurate knowledge of the sky has always helped navigators find their way around, whether across an ocean or in deep space.

Humanity's fascination with the sky may have begun with shepherds, farmers, and navigators using the sky for daily needs, but today that interest has blossomed into a science. Professional astronomers use advanced technology and techniques to measure and chart objects and events very precisely. New discoveries come constantly, adding to a priceless treasury of knowledge about the universe and our place in it. In addition, the tools and technologies of astronomy and space exploration find their way into our technologies. If you fly in a plane, use a smartphone, have surgery, surf the Internet, shop for clothes, eat food, ride in a car, or any of the countless things you do each day, you use technology that in some way derived from astronomy and space science.

CHAPTER 2

ASTRONOMY LINGO

DISTANCE

Distances in astronomy get very large very fast. Astronomers use the term astronomical unit (shortened to AU) to define the distance between Earth and the Sun. It's equivalent to 149 million kilometers (93 million miles). (Astronomy is done in metric units.) So, for distances inside the solar system, we tend to use AU. For example, Jupiter (depending on where it is in its orbit) is 5.2 AU away from the Sun, which is a distance of 774.8 million kilometers (483.6 million miles).

In interstellar space, we use other units. The light-year (shortened to ly) comes from multiplying the speed of light, 300,000 kilometers per second, by the total seconds in a year. The result is the distance light travels in a year: 9.5 trillion kilometers. The nearest star is 4.2 light-years away from us. That means that it's four times 9.5 trillion kilometers, which is a huge number. It's easier to say that the star is 4.2 light-years away.

Astronomers also use the term parsec (or pc for short). One parsec equals 3.26 light-years. The famous Pleiades star cluster is around 150 parsecs (about 350–460 light-years) away. The nearest spiral galaxy, called the Andromeda Galaxy, is about 767 kiloparsecs or 2.5 million light-years from us.

Really huge distances are measured in terms of megaparsecs (millions of parsecs, or Mpc). The closest cluster of galaxies to our own Milky Way Galaxy lies about sixteen megaparsecs, or nearly 59 million light-years, away. The very largest distances are measured in units of gigaparsecs (billions of parsecs, Gpc).

The limit of the visible universe lies about 14 Gpc away from us (about 45.7 billion light-years).

LIGHT

Light is the most basic property we study in astronomy. Studying the light emitted, reflected, or absorbed by an object tells a great deal about the object. The speed of light is the fastest velocity that anything can move in the universe. It is generally stated as 299,792,458 meters (186,282 miles) per second, in a vacuum. It has been measured very accurately and is the standard that astronomers and physicists use. However, as light passes through water, for example, it slows down to 229,600,000 meters (140,000 miles) per second. The letter c is shorthand for the speed of light.

Lightspeed does more than define distances. They help us get an idea of the age of the universe. Step out and look at the Moon. The "Moon" your eyes see is 1.28 seconds old. The Sun is 8.3 light-minutes away—you see the Sun as it was 8.3 minutes ago. The light from the next closest star, called Proxima Centauri, shows us how it looked just over four

years ago. The light from a galaxy that lies 65 million light-years away left that galaxy when the dinosaurs were facing extinction. The most distant objects and events existed when the universe itself was only a few hundred thousand years old. Astronomers see them as they were more than 13 billion years ago. When you look out in space, you're looking back into time. The farther across space you look, the further back in time you see. This means the telescopes and instruments we use to study the cosmos are really time machines.

REDSHIFT AND BLUESHIFT

Spectra and spectroscopy. These are important tools in the astronomer's kit. They take light from an object and slice it up into its component wavelengths. The result is a spectrum. If you've ever passed light through a prism and noticed the

spread of colors that come out, you've seen the principle that spectroscopy works under—except, there are more "colors" in the spectrum that we can't see. Our eyes can only detect the colors you see coming from the prism.

Spectroscopy gives information about how fast or slow an object is moving, and helps astronomers figure out how far away it is. An object moving toward us shows lines in its spectrum that are blueshifted, or shifted to the blue end of the spectrum. If it moves away from us, then the lines are redshifted —shifted toward the red end of the spectrum. The

term redshift is often used to indicate an object's distance, say a redshift of 0.5. Astronomers notate that as $z = 0.5$.

VISIBLE LIGHT

Visible light consists of the following colors: red, orange, yellow, green, blue, indigo, and violet.

CHAPTER 3

THE SOLAR SYSTEM

Our Neighborhood in Space

The solar system is our local place in space. It contains the Sun, eight planets, several dwarf planets, comets, moons, and asteroids. The Sun contains 99.8 percent of all the mass in the solar system. In orbit around it, in a region called the inner solar system, are:

Mercury Venus Earth Mars

Beyond Mars, there's the Asteroid Belt, a collection of rocky objects of various sizes. The outer solar system is dominated by four giant planets that orbit the Sun at large distances and contain about 99 percent of the rest of the solar system's mass. These are:

Jupiter Saturn Uranus Neptune

In recent years, planetary scientists (people who study solar system bodies) have focused much attention on a region beyond the gas giants called the Kuiper Belt. It extends from the orbit of Neptune out to a distance of well beyond 50

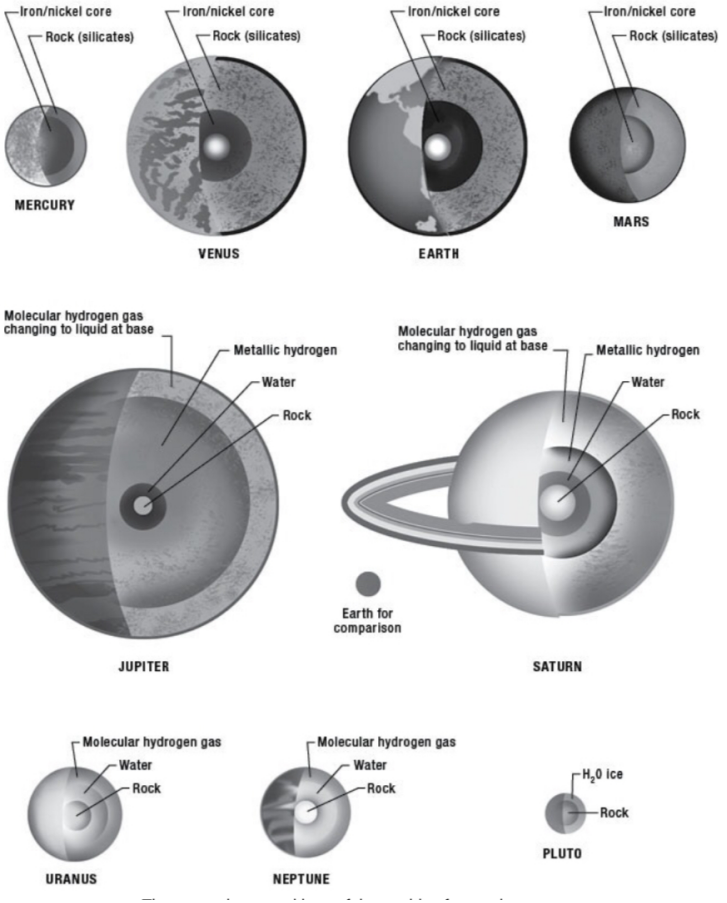
AU from the Sun. Think of it as a very distant and much more extensive version of the Asteroid Belt. It's populated with dwarf planets—Pluto, Haumea, Makemake, and Eris, for example—as well as many other smaller icy worlds.

INVENTORY OF THE SOLAR SYSTEM

1. Star
2. 8 Main Planets
3. 10 Dwarf Planets
4. 146 Moons
5. 4 Ring Systems
6. Countless comets
7. Hundreds and Thousands of Asteroids

Planetary scientists often refer to the inner worlds of the solar system as the

"terrestrial" planets, from the word terra, which is Latin for "earth." It indicates worlds that have a similar rocky composition to Earth. Earth, Venus, and Mars have substantial atmospheres, while Mercury appears to have a very thin one. The big outer worlds are called the "gas giants." These planets consist mostly of very small rocky cores buried deep within massive spheres made of liquid metallic hydrogen, and some helium, covered by cloudy atmospheres. The two outermost planets—Uranus and Neptune—are sometimes described as "ice giants" because they also contain significant amounts of supercold forms of oxygen, carbon, nitrogen, sulfur, and possibly even some water.



THE OORT CLOUD

The entire solar system is surrounded by a shell of frozen bits of ice and rock called the Oort Cloud. It stretches out to about a quarter of the way to the nearest star. Both the Kuiper Belt and the Oort Cloud are the origin of most of the comets we see.

MOONS AND RINGS

Nearly all the major planets, some of the dwarf planets, and some asteroids have natural satellites

called moons. The one we're most familiar with is Earth's Moon. The lunar (from the name Luna)

surface is the only other world on which humans have set foot. Mars has two moons, called

Phobos and Deimos, and Mercury and Venus have none.

The gas giants swarm with moons. Jupiter's four largest are Io, Europa, Ganymede, and

Callisto, and they're often referred to as the Galileans,

Solar System Worlds and Orbits

PLANET	AVERAGE DISTANCE FROM SUN (KM)	ORBITAL PERIOD (EARTH YEAR/EARTH DAYS)
Mercury	57,900,000	0.24 Earth year (88 Earth days)
Venus	108 million	0.62 Earth year (226.3 Earth days)
Earth	149 million	1 Earth year (365.25 days)
Mars	227 million	1.88 Earth years (686.2 Earth days)
Jupiter	779 million	11.86 Earth years (4,380 Earth days)
Saturn	1.425 billion	29.5 Earth years (10,767.5 Earth days)
Uranus	2.85 billion	84 Earth years (30,660 Earth days)
Neptune	4.5 billion	165 Earth years (60,225 Earth days)
Pluto	5.06 billion	248 Earth years (90,520 Earth days)

honoring their discoverer, astronomer

Galileo Galilei. Over the past few decades, at least sixty more have been discovered orbiting

Jupiter. Saturn, Uranus, and Neptune also sport dozens of smaller icy worlds. Out in the Kuiper

Belt, dwarf planet Pluto has at least five satellites, while Eris has at least one.

Each gas giant planet has a set of rings. Saturn's is the most extensive and beautiful. It's

possible Earth had a ring in its early history, and planetary scientists now look at rings as

somewhat ephemeral (short-lived) objects.

ORBITING THE SUN

All the planets of the solar system travel around the Sun following paths

called orbits. Those paths are defined by Kepler's Laws, which state that orbits

are elliptical (slightly flattened circles), with the Sun at one focus of the ellipse.

The farther out an object orbits, the longer it takes to go around the Sun. If you

connect a line between the Sun and the object, Kepler's Law states that this line

sweeps out equal areas in equal amounts of time as the object goes around the

Sun.

CHAPTER 4

THE SUN

Living with a Star:

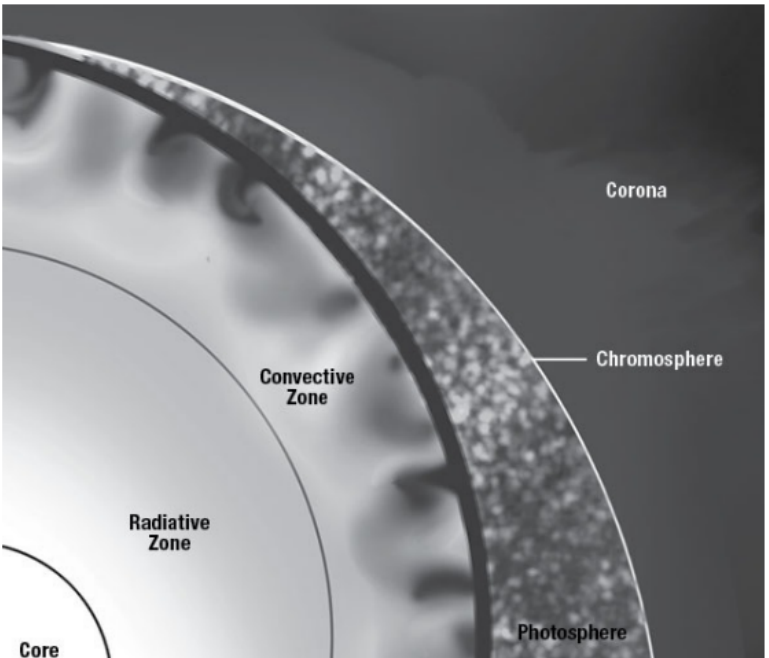
The Sun is a star and the biggest source of heat and light in our solar system. It's

one of at least several hundred billion stars in the Milky Way Galaxy. Without it,

life might not exist, and that makes it very important to us. To early people the

Sun was something to worship. Ancient Greeks venerated Helios as the sun god,

but they had insatiable scientific curiosity about it. They had lively debates over



the true nature of this bright thing in the sky. In the 1600s, Italian astronomer

Galileo Galilei (1564–1642) speculated about what the Sun could be. So did

Johannes Kepler (1571–1630) a few decades later. In the 1800s, astronomers

developed scientific instruments to measure the Sun's properties, which marked

the beginning of solar physics as a scientific discipline.

SOLAR PHYSICS

The study of the physics of the Sun is called solar physics and is a very active area of research.

Solar physicists seek to explain how our star works and how it affects the rest of the solar system.

They measure the Sun's temperatures, figure out its structure, and have assigned it a stellar

"type" based on their measurements. Their work allows us to learn more about all stars by

studying our own.

STRUCTURE OF THE SUN

The Sun is essentially a big sphere of superheated gas. An imaginary

voyage into its heart shows its structure.

First, we have to traverse the outer solar atmosphere, called the corona. It's

an incredibly thin layer of gas superheated to temperatures well over a million degrees.

Once we're through the corona, we're in the chromosphere. It's a thin, reddish-hued layer of gases, and its temperature changes from 3,500° C (6,300°F) at the base to about 34,726 C (62,500°F) where it transitions up to the corona.

Beneath the chromosphere is the photosphere, where temperatures range from 4,226°C (7,640°F) to 5,700°C (10,340°F). When you look at the Sun, the photosphere is what you actually see. The Sun is actually white, but it appears yellowish because its light travels through our atmosphere, which removes blue and red wavelengths from the incoming light.

After we dive below the photosphere, we're in a layer called the convective zone. If you've ever boiled water or syrup, you might recall seeing little granular bubbles. The Sun's convective zone has these granular areas, too. They form as hot material from deep inside rises to the surface. These bubbles are actually currents moving through the Sun.

The next layer down is the radiative zone. This is a very descriptive name

because this region truly does radiate heat from the center of the Sun up to the convective zone.

Finally, beneath the radiative zone is the solar core. This is the inner sanctum—a huge nuclear furnace. It's the place where nuclear fusion takes place. How does that happen? The temperature in the core is about 15 million degrees Celsius (27 million degrees Fahrenheit). The rest of the Sun pressing down on it provides a pressure 340 billion times Earth's atmospheric pressure at sea level. Those extreme conditions create a huge pressure cooker in which atoms of hydrogen slam together to form atoms of helium. The Sun fuses about 620 metric tons of hydrogen to helium each second, and that's what provides all of the heat and light.

CHAPTER 5

SPACE WEATHER

The Sun-Earth Connection:

Have you ever seen or heard about the northern or southern lights? These upper atmosphere light shows are actually a very benign form of space weather, a term that describes changes in the near-Earth space environment mainly due to activity originating at the Sun. Such aurorae are upper atmosphere disturbances caused by solar activity. They occur about 80 to 90 kilometers (50–60 miles) above the polar regions of our planet. They are just one manifestation of a constant connection between Earth and the Sun. It's a connection that provides more than heat and light to our planet.

WHEN SPACE WEATHER ATTACKS

The Sun constantly emits a stream of charged particles called the solar wind. As this wind rushes past Earth, it runs into our magnetosphere. That's the region of space around Earth that is bound by our magnetic field. Most of the

wind slides right on by, but some of the charged particles get caught up in the magnetic field lines. They spiral in toward the polar regions since those areas are where the magnetic field lines originate. The charged particles energize molecules of gas in our upper atmosphere, called the ionosphere. This causes them to glow. That glow is called the aurora. If it appears over the north pole, it's called the aurora borealis; over the south pole it is called the aurora australis.

Most of the time it glows white or green. However, if the solar storm is fairly energetic, more and different gases are energized and we can see reds and purples in spectacular auroral displays.

SPACE WEATHER AND GPS

Global positioning satellite (GPS) data flows through our technological society. When you fly, take a train, cruise on a ship, or drive in a GPS-equipped car or truck, you're relying on satellite timing signals that travel through our atmosphere to receivers on the ground. That data helps calculate your position. Other systems also rely on GPS timing signals—these systems range from cellular telephones to financial transfer networks that move money around the globe. When a

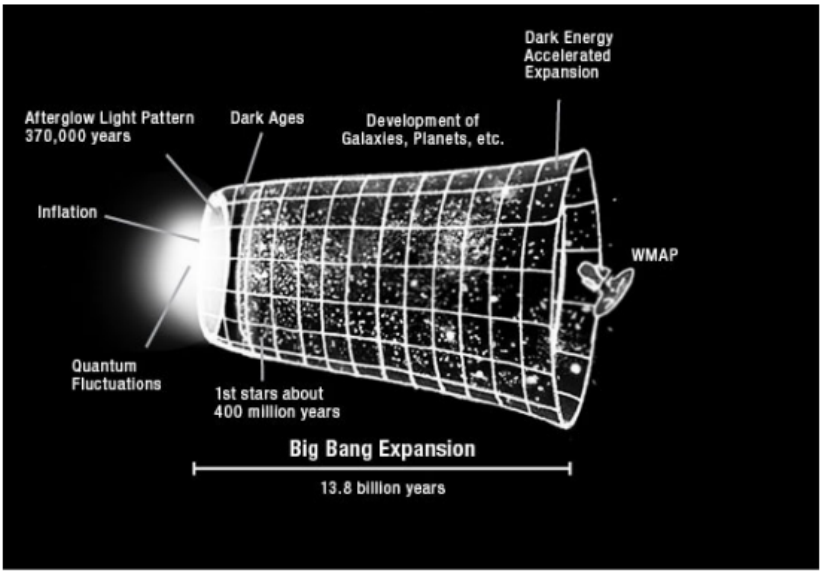
geomagnetic storm occurs, it increases the electron density (the number of electrons) in our upper

atmosphere. Signals trying to propagate (move) through to the ground get delayed, which causes

errors in their data. This means that systems depending on GPS have to shut down. If they're in

planes, trains, or other modes of transportation, the operators must switch to other modes of

navigation



CHAPTER 6

THE BIG BANG

One of the most tantalizing questions we can ask in astronomy is, “How did all this material that we detect in the cosmos get started?” To answer it, astronomers look back across 13.8 billion years to a time when the universe was in a seething, hot, dense state of existence. How long it was that way and what came before it are still unknown. Yet, from that first state of existence sprang the entire universe we know today. The origin of the universe and how it has evolved to the complex and large structures we see today are the subject of a science called cosmology.

THE BEGINNING

The Big Bang—the birth of the universe—occurred some 13.8 billion years ago. It was an event that filled all of the space there was at that time with matter and energy. It was the beginning of space and time. The Big Bang wasn’t an

explosion, as the name seems to suggest. Rather, the birth of the universe set off

an expansion of space and time that continues to this day. The most primordial

particles of matter were created in the event.

The first second after the Big Bang, the entire universe was a soup of

subatomic particles, superheated to 10 billion degrees. In that first second,

amazing things happened:

The force of gravity separated out from the electronuclear force and was

joined soon thereafter by the electromagnetic force.

The universe changed from being a hot soup of quarks and gluons

(elementary particles), and protons and neutrons began to form.

At the ripe old age of one second, the newborn universe was cool enough

that it began forming deuterium (a form of hydrogen) and helium-3. At this

point, the newborn universe had doubled in size at least ninety times!

Over the next three minutes, the infant universe continued to cool down and

expand, and the creation of the first elements continued. For the next 370,000

years, the universe continued its expansion. But it was a dark place, too hot for

any light to shine. There existed only a dense plasma, an opaque hot soup that

blocked and scattered light. The universe was essentially a fog.

The next big change in the universe came during the era of recombination,

which occurred when matter cooled enough to form atoms. The result was a

transparent gas through which the original flash of light from the Big Bang could

finally travel. We see that flash today as a faint, all-encompassing, distant glow

called the cosmic microwave background radiation (sometimes shortened to

CMB or CMBR). The universe was leaving its cosmic dark ages behind. Gas

clouds condensed under their own self-gravity (possibly helped along by the

gravitational influence of dark matter) to form the first stars. These stars

energized (or ionized) the remaining gas around them, lighting up the universe

even more. This period is called the Epoch of Reionization.

THE END